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स्वचल वाहन — स्फुलिंग दहन इंजिनों से युक्त वाहनों से वाष्पनिक उत्सर्जन — मापन पद्धति

Indian Standard

AUTOMOTIVE VEHICLES — EVAPORATIVE EMISSIONS FROM VEHICLES EQUIPPED WITH SPARK IGNITION ENGINES — METHOD OF MEASUREMENT

ICS 43.060; 13.040.50

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BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

December 1998

Price Group 7

Automotive Primemovers Sectional Committee, TED 2

FOREWORD

This Indian Standard was adopted by the Bureau of Indian Standards, after the draft finalized by the Automotive Primemovers Sectional Committee had been approved by the Transport Engineering Division Council.

The manifold increase in the population of four wheelers in our country has further increased the emissions emanating from the vehicles and serious environment and health hazards. The Govt under Central Motor Vehicle Rules specified that the four wheeled vehicles equipped with spark ignition (gasoline) engines shall comply with the limits of evaporative emissions specified in them. In view of the above, the committee felt the need to evolve a standard to determine the evaporative emission from the four wheeled spark ignition engined vehicles and assessment of conformity of the vehicles to the values stipulated by the Govt from time to time.

While preparing the standard considerable assistance has been derived from:

EEC/91/441	Air pollution by emission from motor vehicles
Annexure III of Ranganathan Committee Report	Details of Standards for Emission of Gaseous Pollutants from Petrol Engined Vehicles and Test Procedures Effective from 01.04.1991.(Part VIII of Doc: MOST/CMVR/TAP 115-116 Details of Standards of evaporative and crankcase emissions from petrol engines and test procedures effective from 1.4.96)

The committee responsible for the preparation of this standard is given in Annex D.

In reporting the results of a test or analysis made in accordance with this standard, if the final value, observed or calculated, is to be rounded off, it shall be done in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'.

Indian Standard

AUTOMOTIVE VEHICLES — EVAPORATIVE EMISSIONS FROM VEHICLES EQUIPPED WITH SPARK IGNITION ENGINES — METHOD OF MEASUREMENT

1 SCOPE

This standard specifies the method for determination of the loss of Hydrocarbons (HC) by evaporation from the fuel systems of four wheeled vehicles equipped with Spark Ignition (gasoline) engines.

2 REFERENCES

The Indian Standards listed below contain provisions which through reference in this text, constitute provision of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below:

IS No.	*Title*
1448	Methods of test for petroleum and its products:
[P : 16] : 1990	Density of crude petroleum and liquid petroleum products by hydrometer method (*third revision*)
[P : 18] : 1990	Distillation (*second revision*)
[P : 23] : 1990	Hydrocarbon types in liquid petroleum products by fluorescent indicator absorption method (*third revision*)
[P : 26] : 1990	Knock characteristics of motor fuels by the motor method
[P : 28] : 1990	Oxidation stability of motor gasoline and aviation fuels (*second revision*)
[P : 29] : 1990	Existent gum in fuels by jet evaporation (*second revision*)
[P : 34] : 1990	Determination of sulphur in petroleum products (lamp method) (*second revision*)
[P : 38] : 1990	Lead antilock compounds in gasoline by gravimetric method (*second revision*)
[P : 39] : 1990	Vapour pressure by Reid method (*first revision*)
[P : 82] : 1990	Total lead content in gasoline by iodine monochloride method
14600 : 1998	Automotive vehicles — Exhaust emissions — Gaseous pollutants from vehicles equipped with spark ignition engines — Method of measurement

3 TERMINOLOGY

For the purpose of this standard the following definitions shall apply.

3.1 Calibrating Gas

A precisely analysed gas mixture of a known concentration used to calibrate the analytical instruments on a periodic basis and in conjunction with similar calibrating gas blends of differing concentration.

3.2 Chassis Dynamometer

A laboratory power absorption unit capable of simulating to a limited degree the road operation of a vehicle. The dynamometer shall possess capability to simulate the inertia and road load power developed by a vehicle.

3.3 Driving Cycle

A sequence of an engine or vehicle operating modes usually designed to simulate road usage of the vehicle.

3.4 Evaporating Emissions

Fuel vapours (Hydrocarbons) emitted into the atmosphere from the vehicle.

3.5 Flame Ionization Detector (FID)

An analytical instrument used for determining the carbon concentration of hydrocarbons in exhaust gas.

4 GENERAL REQUIREMENTS

4.1 The vehicle shall be in good mechanical condition and shall have been run in atleast 3 000 km or the value as recommended by the manufacturer before the test. The evaporative emission control system shall be connected and functioning correctly over this period and the carbon canister subjected to normal use, neither under going abnormal purging nor abnormal loading.

4.2 The appropriate reference fuel used for the test is specified in Annex A.

5 TEST EQUIPMENT

5.1 Chassis Dynamometer

5.1.1 The chassis dynamometer used for the measurement of evaporative emissions shall meet the requirements stipulated in **4.2.6** of IS 14600.

5.2 Evaporative Emission Measurement Enclosure

The evaporative emission measurement enclosure shall be a gas-tight rectangular measuring chamber able to contain the vehicle under test. The vehicle shall be accessible from all sides and the enclosure, when sealed, shall be gas-tight in accordance with Annex B. The inner surface of the enclosure shall be impermeable to hydrocarbons. Atleast one of the surfaces shall incorporate a flexible impermeable material to allow equalization of pressure changes resulting from small changes in temperatures. Wall design shall be such as to promote good dissipation of heat. The temperature of the wall shall not drop below 20°C at any point during testing.

5.3 Analytical Test Equipment

5.3.1 *Hydrocarbon Analyser*

5.3.1.1 The atmosphere within the chamber shall be monitored by using a hydrocarbon detector of the flame ionization detector (FID) type. Sample gas shall be drawn from the mid point of one side wall or roof of the chamber and any by-pass flow shall be returned to the enclosure, preferably at a point immediately down stream of the mixing fan.

5.3.1.2 The Hydrocarbon analyser shall have a response time to 90 percent of final reading of less than 1.5 seconds and its stability shall be better than 2 percent of full scale at zero and at 80 ± 20 percent of full scale over a 15 minutes period for all operational ranges.

5.3.1.3 The repeatability of the analysers expressed as standard deviation shall be better than 1 percent of full scale deflection at zero and at 80 ± 20 percent of full scale on all the ranges used.

5.3.1.4 The operational ranges of the analyser shall be chosen to give the best resolution over the measurement, calibration and leak checking procedure.

5.3.2 *Hydrocarbon Analyser Data Recording System*

The Hydrocarbon analyser shall be fitted with a device to record the electrical signal output either by a strip chart recorder or by other data processing system at a frequency of atleast once in a minute. The recording system shall have operating characteristics atleast equivalent to the signal being recorded and shall provide a permanent record of results. The record shall show a positive indication of the beginning and the end of the fuel tank heating and hot soak period together with the time elapsed between start and completion of each test.

5.4 Fuel Tank Heating System

5.4.1 The fuel in the vehicle tank(s) shall be heated by a controllable source of heat preferably by a heating pad of 2 Kw. The heating pad shall apply heat evenly to the tank walls between the level of the fuels so as not to cause any local overheating of the fuel. Heat shall not be applied to the vapour in the tank above the fuel.

5.4.2 The heating device shall make it possible to evenly heat the fuel in the tank to 30°C from 16°C within a duration of 60 minutes with the temperature sensor positioned as specified in **6.1.1**. The heating system shall be capable of controlling fuel temperature to within ± 1.5°C of the required temperature during the tank heating process.

5.5 Temperature Recording System

5.5.1 The temperature in the chamber shall be recorded at two points by temperature sensors which are connected so as to show a mean value. The measuring points shall be extended approximately 0.1 m into the enclosure from the vertical centre line of each side wall at a height of 0.9 ± 0.2 m.

5.5.2 The temperature of the fuel tank(s) shall be recorded by means of the sensor positioned in the fuel tank as detailed in **5.1.1**.

5.5.3 The temperatures shall (throughout. the evaporative emission measurement) be recorded or entered into a data processing system at a frequency of atleast one per minute.

5.5.4 The accuracy of the temperature recording system shall be within ± 1°C and the temperature shall be capable of being resolved to 0.4°C.

5.5.5 The recording or data processing system shall be capable of resolving time to ± 15 s.

5.6 Fans

5.6.1 By the use of one or more fans or blowers with the SHED door(s) open, it shall be made possible to reduce the Hydrocarbon concentration in the chamber to ambient hydrocarbon levels.

5.6.2 The chamber shall have one or more fans or blowers of capacity in the range of 0.1 to 0.5 m^3/s to thoroughly mix the atmosphere within the enclosure. It shall be possible to attain an even temperature and hydrocarbon concentration in the chamber during measurements. The vehicle in the enclosure shall not be subjected to a direct stream of air from the fans or blowers.

5.7 Calibrating Gases

5.7.1 The following pure gases shall be used for calibration and operation purposes,

a) Purified synthetic air (purity $\leq$ 1 ppm C1 equivalent, $\leq$ 1 ppm CO, $\leq$ 400 ppm CO_2, $\leq$ 0.1 ppm NO) and O_2 content between 18 to 21 percent by volume.

b) Hydrocarbon analyser fuel gas (40 ± 2 percent H_2 and balance He with less than 1 ppm C_2 equivalent Hydrocarbon and less than 400 ppm CO_2).

c) Propane (C_3H_8) of minimum 99.5 percent purity.

5.7.2 Calibration and span gases shall be available containing mixture of C_3H_8 and purified synthetic air. The true concentrations of a calibration gas shall be within ± 2 percent of the stated figures. The accuracy of the diluted gases obtained while using a gas divider shall be within ± 2 percent of the true value. The concentrations specified in Annex B may also be obtained by the use of a gas divider using synthetic air as the dilutant gas.

5.8 Additional Equipment

The absolute humidity in the test area shall be measurable within ± 5 percent and the pressure shall be measurable within ± 0.1 kPa.

6 TEST PROCEDURE

6.1 Test Preparation

6.1.1 Prior to test the following shall be ensured:

a) The exhaust system of the vehicle shall not exhibit any leaks.

b) The vehicle shall be steam cleaned.

c) The fuel tank (s) of the vehicle shall be equipped with a temperature sensor to enable the temperature to be measured at the mid point of the fuel in the fuel tank when filled to 40 percent of its capacity.

d) Additional fittings, adapters of devices shall be fitted to allow complete draining of the fuel tank.

6.1.2 The test (schematic) schedule is described in Annex C.

6.1.3 The vehicle shall be taken into the test area where the ambient temperature is between 20 and 30°C.

6.1.4 The canister of the vehicle shall be purged for 30 minutes by driving the vehicle at 60 km/h at the dynamometer setting as specified in **4.2.7** of IS 14600. Alternatively the canister may be purged by passing air (at ambient temperature and humidity) through it at a flow rate which shall be identical to the actual air flow through the canister when operating the vehicle at 60 km/h. The canister shall be subsequently loaded with two diurnal emission tests.

6.1.5 The fuel tank(s) shall be emptied using the fuel tank drain(s) provided for this purpose. This shall be done so as not to abnormally purge nor abnormally load the evaporative control devices fitted to the vehicle. [Removal of the fuel cap(s) is normally considered sufficient to achieve this purpose].

6.1.6 The fuel tank(s) shall be filled with specified test fuel at a temperature between 10°C and 14°C to 40 ± 2 percent of its (their) normal fuel capacity. The vehicles fuel cap(s) shall not be replaced at this point.

6.1.7 In the case of vehicles fitted with more than one fuel tank, all the tanks shall be heated in the same way, as described below. The temperatures of the tanks shall be identical to within ± 1.5°C.

6.1.8 The fuel may be initially heated to the starting temperature of 16 ± 1°C.

6.1.9 As soon as the fuel reaches the temperature of 14°C, the fuel tanks(s) shall be sealed. When the temperature of the fuel tank reaches 16 ± 1°C, a linear heat build of 14 ± 0.5°C over a period of 60 ± 2 minutes begins. The temperature of the fuel during the heating shall conform to the function below to within ± 1.5°C:

$$T_f = T_o + \frac{7}{30}(t)$$

where

T_f = required temperature (°C),

T_o = initial temperature of tank (°C), and

t = time from start to the tank heat build in minutes.

The elapsed time of the heat build and temperature rise shall be recorded.

6.1.10 After a period of not more than one hour, the operations of fuel draining and filling shall begin according to **6.1.5** to **6.1.8**.

6.1.11 Within two hours of the end of the first diurnal heating period the second diurnal heating operation shall begin as specified in **6.1.9** and be completed with the recording of the temperature rise and elapsed time of the heat build.

6.1.12 Within one hour of the end of the second diurnal heat build the vehicle is placed on a chassis dynamometer and driven six Indian Driving Cycle and a drive for a duration of 10 minutes at a speed of 60 km/h on a chassis dynamometer. Samples of the exhaust emissions shall not be collected during this operation.

6.1.13 Within five minutes of completing the preconditioning operation specified in **6.1.12**, the engine bonnet shall be completely closed and the vehicle shall be driven off the chassis dynamometer and parked in the soak area. The vehicle shall be parked for a minimum of 10 h and a maximum of 36 h. The engine oil and coolant temperatures shall have reached the temperature of the soak area to within ± 2°C at the end of this period.

6.2 Tank Breathing Evaporation Emission Test

6.2.1 The operation specified in **6.2.4** may begin not less than 9 h and not more than 35 h after the preconditioning driving cycle.

6.2.2 Prior to testing, the measuring chamber shall be purged for several minutes until a stable background level in the chamber is attained while the mixing fan(s) are in operation.

6.2.3 Prior to test, the Hydrocarbon analyser shall be zeroed and spanned.

6.2.4 The fuel tank(s) shall be emptied as specified in **6.1.5** and refilled with test fuel at a temperature between 10 and 14°C to 40 ± 2 percent of the tank(s) normal volumetric capacity. The fuel cap(s) of the vehicle shall not be fitted at this point.

6.2.5 In case of vehicles fitted with more than one fuel tank, all those tanks shall be heated in the similar way as specified in **6.2.6** and **6.2.7**. The temperatures of the tanks shall be at uniform temperature to within ± 1.5°C.

6.2.6 The test vehicle shall be brought into the test enclosure with the engine switched off and the windows and the luggage compartments in open condition. The fuel tank sensors and the fuel tank heating device, if necessary, shall be connected. Record the fuel temperature and the air temperature within the enclosure immediately. The purging fan if still operating shall be switched off at this time.

6.2.7 The fuel may be artificially heated to the starting temperature of 16 ± 1°C.

6.2.8 As soon as the fuel temperature(s) reaches 14°C, the fuel tank(s) and the chamber shall be sealed in such a way that they remain gas-tight.

6.2.9 As soon as the fuel reaches a temperature of 16 ± 1°C.

a) The Hydrocarbon concentration, barometric pressure and the temperature shall be measured to give the initial reading CHCi, Pi, and Ti for the tank heat build test.

b) A linear heat build of 14 ± 0.5°C over a period of 60 ± 2 minutes shall begin. The temperature of the fuel during the heating shall conform to the function below within ± 1.5°C.

6.2.10 The temperature of the fuel during heating shall be obtained from the following formula:

$$T_t = T_o + \frac{7}{30}(t)$$

where

T_t = Required temperature (°C),

T_o = Initial temperature of tank (°C), and

t = Time from start of heat build in minutes.

6.2.11 The Hydrocarbon analyser shall be zeroed and spanned immediately before the end of test.

6.2.12 If the temperature has risen by 14 ± 0.5°C over the 60 ± 2 min period of the test, the final

Hydrocarbon concentration in the enclosure shall be measured (C_{HCf}). The time or elapsed time of this together with the final temperature and barometric pressure (T_f and P_f) for the hot soak shall be recorded.

6.2.13 The heat source shall be turned off and the enclosure door shall be unsealed and opened. The heating device and temperature sensor shall be disconnected from the enclosure apparatus. The vehicle doors and luggage compartment may now be closed and the vehicle removed from the enclosure with the engine switched off.

6.2.14 The vehicle shall be prepared for the subsequent driving cycles and hot soak evaporative emission test. The cold start test shall follow the tank breathing test within one hour.

6.2.15 The testing agency may consider that the design of the vehicle's fuel system may allow losses to the outside atmosphere at any point. In such case an engineering analysis shall be carried out to the complete satisfaction of the testing agency to establish that vapours are vented to the carbon canister and that these vapours are adequately purged during vehicle operation.

6.3 Driving Cycle

The determination for evaporative emissions is concluded with the measurement of Hydrocarbon emissions over a 60 min hot soak period following six Indian Driving Cycles and additional 15 minutes drive at 60 km/h on chassis dynamometer. Following the tank breathing losses test, the vehicle is pushed or otherwise manoeuvred onto the chassis dynamometer with the engine switched off. It is then driven through six urban driving cycle as described in 4.2.2 of IS 14600 and additional 15 minutes drive at 60 km/h on chassis dynamometer. Exhaust emissions may be sampled during this operation but the results shall not be used for exhaust emission type approval purposes.

6.4 Hot Soak Evaporative Emission Test

6.4.1 The measuring chamber shall be purged for several minutes immediately before the test until a stable background is obtainable with the mixing fan(s) on.

6.4.2 Prior to test, the Hydrocarbon analyser shall be zeroed and spanned.

6.4.3 At the end of additional driving for 15 minutes at 60 km/h on chassis dynamometer, the engine bonnet shall be completely closed and all connections between the vehicle and the test stand shall be disconnected. The vehicle shall be then driven to the measuring chamber with the minimum use of accelerator pedal. The engine shall be turned off before any part of the vehicle enters the measuring chamber. The time at which the engine is switched off shall be recorded on the evaporative emission measurement data recording system and proceed with the temperature recording. The vehicle windows and luggage compartments shall be opened at this stage, if not already opened.

6.4.4 The vehicle shall be pushed or otherwise moved into the measuring chamber with the engine switched off.

6.4.5 The enclosure doors shall be closed and sealed gas-tight within two minutes of the engine being switched off and within five minutes at the end of the driving cycle.

6.4.6 The start of a 60 ± 0.5 min of hot soak period begins after sealing of the chamber. The Hydrocarbon concentration, temperature and barometric pressure shall be measured to give the initial readings C_{HCi}, P_i and T_i for the hot soak test. The ambient SHED temperature T shall not be less than 23°C and not more than 31°C during the 60 minutes hot soak period.

6.4.7 The Hydrocarbon analyser shall be zeroed and spanned immediately before the end of the 60 ± 0.5 min test period.

6.4.8 At the end of the 60 ± 0.5 min test period measure the Hydrocarbon concentration in the chamber. The temperature and the barometric pressure shall also be measured. These are the final readings C_{HCf}, P_f and T_f for the hot soak test.

7 CALCULATIONS

7.1 The evaporative emission tests specified in 6 allow the Hydrocarbon emissions from the tank breathing and hot soak phases to be calculated for each of these phases as below :

$$M_{HC} = K \times V \times 10^{-4} \left[\frac{(C_{HCf} \times P_f)}{T_f} - \frac{(C_{HCi} \times P_i)}{T_i} \right]$$

where

M_{HC} = Mass of the Hydrocarbon emitted over the test phase (gm);

V = Net enclosure volume in cubic metres corrected for the volume of the vehicle, with the windows and luggage compartments open. If the volume of the vehicle is not determined, a volume of 1.42 m^3 may be subtracted;

H/C = Hydrogen to carbon ratio;

K = $1.2\,(12 + H/C)$;

H/C = 2.33 for tank breathing losses;

H/C = 2.20 for hot soak losses;

C_{HCi} = Measured initial HC concentration in the enclosure, ppm (volume) (equivalent);

C_{HCf} = Measured final HC concentration in the enclosure;

P_i = Initial barometric pressure, kPa;

P_f = Final barometric pressure, kPa;

T_i = Initial ambient temperature, °C; and

T_f = Final ambient temperature, °C.

7.2 Overall Result of Test

The overall Hydrocarbon mass emission for the vehicle shall be calculated from the following formula:

$$M_{TOTAL} = M_{TH} + M_{HS}$$

where

M_{TOTAL} = Overall mass emission of the vehicle in grams,

M_{TH} = Hydrocarbon mass emission for the tank heat build in grams, and

M_{HS} = Hydrocarbon mass emission for the hot soak in grams.

ANNEX A

(*Clause* 4.2)

A-1 The reference fuel (leaded gasoline), to be used for emission testing of vehicles equipped with spark ignition engine shall comply the following requirements:

Characteristics	*Limits*	*Method of Test (Ref to the Part of IS 1448)*
Research Octane Number	87.0 *Min*	P : 26
Specific Gravity at 288 K	0.73 - 0.75	P : 16
Reid Vapour pressure, kg/cm^2	0.45 to 0.65	P : 39
Distillation, K		P : 18
Initial boiling point	298 - 318	
10 percent recovery	323 - 343	
50 percent recovery	358 - 378	
90 percent recovery	393 - 433	
Final boiling point	473 *Max*	
Residue, percent vol	2 *Max*	
Hydrocarbon analysis, percent vol		
Olefins	20 *Max*	P : 23
Aromatics	45 *Max*	
Saturates	balance	
Oxidation stability, minutes	480 *Min*	P : 28
Existent gum, mg/100 ml	4.0 *Max*	P : 29
Sulphur content, percent mass	0.10 *Max*	P : 34
Lead content, g/l	0.40 *Max*	P : 38 or P : 82

NOTES

1 Only conventional refinery components shall be used while blending the fuel.

2 The values quoted in the specification are 'true values'. While fixing a minimum value, a minimum difference of 2R above zero has been taken into account and in fixing a maximum and minimum value, the minimum difference is 4R (R = reproducibility). Notwithstanding this measure, which is necessary for statistical reasons, the manufacturer of fuel shall nevertheless aim at a zero value where the stipulated maximum value is 2R and at the mean value in the case of quotations of maximum and minimum limits.

3 The figures quoted show the evaporated quantities both recovered and loss in percent.

4 The fuel may contain oxidation inhibitors and metal de-activators normally used to stabilize refinery gasoline streams, but it shall not contain detergent/dispersant additives and solvent oils.

ANNEX B

(*Clauses* 5.2.1 *and* 5.7.2)

CALIBRATION OF EQUIPMENT FOR EVAPORATIVE EMISSION TESTING

B-1 CALIBRATION FREQUENCY AND METHODS

B-1.1 Prior to use all equipments shall be calibrated and the subsequent calibration periodicity shall be as recommended by the manufacturer of the equipment.

B-1.2 The equipment used for type approval and conformity of production (COP) tests shall have been calibrated during that month.

B-2 CALIBRATION OF THE ENCLOSURE

B-2.1 Initial measurement of enclosure internal volume.

B-2.1.1 Before it's initial use, the internal volume of the chamber shall be measured as detailed below.

B-2.1.1.1 The internal dimensions of the chamber shall be measured by providing allowance for irregularities, such as bracing struts. The internal volume of the chamber shall be calculated from these measurements.

B-2.1.2 The net internal volume shall be determined by subtracting 1.42 m^3 from the internal volume of the chamber. Alternatively the volume of the test vehicle with the luggage compartment and windows open may be used.

B-2.1.3 The chamber shall be checked as detailed in **B-2.3**. If the propane mass does not agree with the injected mass to within ±2 percent, then corrective action shall be required.

B-2.2 Determination of Chamber Background Emission

B-2.2.1 This operation determines that the chamber does not contain any materials that emit significant Hydrocarbons (HC). This check shall be carried out at the enclosures introduction to service, after any operations in the enclosure which may effect background emissions and at a frequency of atleast once in a year.

B-2.2.2 Calibrate the analyser (if required), then zero and span it.

B-2.2.3 Purge the enclosure until a stable Hydrocarbon reading is obtained. The mixing fan shall be turned on, if not already on.

B-2.2.4 Seal the chamber and measure the background Hydrocarbon concentration, temperature and barometric pressure these are the initial readings C_{HCi}, T_i, and P_i used in the enclosure background calculations.

B-2.2.5 The enclosure shall be allowed to stand undisturbed with the mixing fan on for a minimum period of four hours.

B-2.2.6 At the end of this period use the same analyser to measure Hydrocarbon concentration in the chamber. The temperature and barometric pressure shall also be measured. These are the final readings C_{HCf}, T_f and P_f.

B-2.2.7 Calculate the change in mass of Hydrocarbons in the enclosure over the time of the test according to **B-2.4**. The background emission of the enclosure shall not exceed 0.4 grams.

B-2.3 Calibration and Hydrocarbon Retention Test of the Chamber

B-2.3.1 The calibration and Hydrocarbon retention test in the chamber provides a check on the calculated volume in **B-2.1** of this annexure and also measures any leak rate.

B-2.3.2 Purge the enclosure until a suitable Hydrocarbon concentration is reached. Turn the mixing fan 'ON', if not already switched on. The hydrocarbon analyser shall be zeroed (calibrated if required) and spanned.

B-2.3.3 Seal the enclosure and measure the background concentration, temperature and barometric pressure. These are the initial readings (C_{HCi}, T_i and P_i) used in the enclosure calibration.

B-2.3.4 Inject a quantity of approximately four grams of propane (C_3H_8) into the enclosure. The mass of C_3H_8 shall be measured to an accuracy of ± 0.5 percent of measured volume.

B-2.3.5 Allow the contents of the chamber to mix for five minutes and then measure the Hydrocarbon concentration, temperature and barometric pressure. These are the final readings (C_{HCf}, T_f and P_f) for the calibration of the enclosure.

B-2.3.6 Using the readings obtained in **B-2.3.3** and **B-2.3.5** and the formula given in **B-2.4**, calculate the mass of propane in the enclosure. This shall be within ± 2 percent of the mass of propane measured in **B-2.3.4**.

B-2.3.7 Allow the contents of the chamber to mix for a minimum of four hours. At the end of this period measure and record the final Hydrocarbon concentration, temperature and barometric pressure.

B-2.3.8 Calculate the Hydrocarbon mass by using the formula of **B-2.4**, from the readings of **B-2.3.7** and **B-2.3.3**. The two masses shall not differ by more than four percent from the hydrocarbon mass given in **B-2.3.6**.

B-2.4 Calculations

The calculation of net Hydrocarbon mass change within the enclosure shall be used to determine the chambers hydrocarbon background and leak rate. Initial and final readings of hydrocarbon concentration, temperature and barometric pressure are used in the following formula to calculate change of mass.

$$M_{HC} = 17.6 \times V \times 10^{-4} \left[\frac{(C_{HCf} \times P_f)}{T_f} - \frac{(C_{HCi} \times P_i)}{T_i} \right]$$

where

M_{HC} = Mass of the Hydrocarbon emitted over the test phase (gm);

V = Net enclosure volume in cubic metres corrected for the volume of the vehicle, with the windows and luggage compartments open. If the volume of the vehicle is not determined, a volume of 1.42 m^3 may be subtracted;

K = 1.2 (12 + H/C);

H/C = Hydrogen to carbon ratio;

H/C = 2.33 for tank breathing losses;

H/C = 2.20 for hot soak losses;

C_{HCi} = Measured initial HC concentration; in the enclosure, ppm (volume) (G equivalent);

C_{HCf} = Measured final HC concentration in the enclosure;

P_i = Initial barometric pressure, kPa;

P_f = Final barometric pressure, kPa;

T_i = Initial ambient temperature, °C; and

T_f = Final ambient temperature, °C.

B-3 CHECKING OF FID HYDROCARBON ANALYSER

B-3.1 Detector Response Optimization

B-3.1.1 The FID shall be adjusted as specified by the instrument manufacturer. Propane in air shall be used to optimize the response on the most common operating range.

B-3.2 Calibration of the Hydrocarbon Analyser

B-3.2.1 The analyser shall be calibrated using propane in air and purified synthetic air.

B-3.2.2 Establish a calibration curve as described in **B-4.1** to **B-4.5**.

B-3.3 Oxygen Interference Check and Recommended Limits

B-3.3.1 The response factor (R_f) for a particular Hydrocarbon specifies the ratio of the FID C1 reading to the gas cylinder concentration expressed in ppm C1.

B-3.3.2 The concentration of the test gas shall be at an appropriate level for that operating range to give a response of approximately 80 percent of full scale deflection. The concentration shall be known, to an accuracy of ± 2 percent in reference to a gravimetric standard expressed in volume. Additionally the gas cylinder shall be preconditioned for 24 h at a temperature between 20 and 30°C.

B-3.3.3 R_f shall be determined when introducing an analyser into service and thereafter at major service intervals. The reference gas to be used is propane with balance purified air that gives a response factor of 1.00.

B-3.3.4 The test gas to be used for oxygen interference and the recommended response factor range shall be as follows:

Propane and Nitrogen $0.95 \leq R_f \leq 1.05$

B-4 CALIBRATION OF THE HYDROCARBON ANALYSER

Each of the normally used operating ranges shall be calibrated in the following manner.

B-4.1 Establish the calibration curve by atleast five calibration points spaced as evenly as possible over the operating range. The nominal concentration of the calibration gas with the highest concentrations shall be atleast 80 percent of the full scale value.

B-4.2 Calculate the calibration curve by the method of least squares. If the resulting polynomial degree is greater than 3, then the number of calibration points shall be atleast the number of the polynomial degree plus two.

B-4.3 The calibration curve shall not differ by more than 2 percent from the nominal volume of each calibration gas.

B-4.4 Using the coefficients of the polynomial derived from **B-3.2**, a table of indicated reading versus true concentration shall be drawn up in steps of not more than one percent of full-scale value. This shall be carried out for each analyser range calibrated. The table shall also contain other relevant details such as:

a) Date of calibration,

b) Span and zero potentiometer readings (where applicable),

c) Reference data of each calibration gas used,

d) The actual and indicated value of each calibration gas used together with the percentage difference,

e) FID fuel and type, and

f) FID air pressure.

B-4.5 Usage of computer or electronic control range switch with equivalent accuracy may be allowed, if it is established that they may also give satisfactory results.

ANNEX C

(*Clause* 6.1.2)

EVAPORATIVE EMISSION DETERMINATION TEST SCHEDULE

3 000 km run-in period or less as per recommendations of the manufacturer (No excessive purge/load) Steam clean of vehicle (if necessary)

Description	*Condition*
Vehicle preconditioning	Purge canister by driving or air purge at 20 to 30°C ambient. (as per **6.1.1** to **6.1.6**).
5 min, *Max* (*see* **6.1.3**)	2 X diurnal heat build 6 IDC + 15 min @ 60 km/h (as per **6.1.7** to **6.1.12**)
Vehicle soaking for 10-36 h	Ambient temperature 20-30°C (as per **6.1.3**)
Fuel drain and fuel tank fill	40 ± 2 percent of nominal tank capacity. Fuel temperature 10 to 14°C (as per **6.2.4** to **6.2.6**)
Diurnal test 16 to 30°C In one hour	Fuel temperature 16 ± 1°C test begins ΔT = 14 ± 0.5°C over 60 ± 2 minutes.
1 h, *Max*	(as per **6.2.7** to **6.2.11**)
Dynamometer test	
7 min, *Max* 2 min from engine Switch off	Drive on chassis dynamometer for 6 IDC + 15 min @ 60 km/h as per **6.3**
Hot soak in chamber One hour, 23 to 31°C	Starting temperature inside SHED shall be a minimum of 23°C. Maximum temperature shall be 31°C (as per **6.4**)
End of the test	Calculated Test Result = Diurnal result (grams) + hot soak result (grams)

ANNEX D

(*Foreword*)

COMMITTEE COMPOSITION

Automotive Primemovers Sectional Committee, TED 2

Chairman

DR M. L. MATHUR
Alok Villa, 17, Sector 'A'
Shastri Nagar, Jodhpur 342003

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